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REPORT ON ECONOMIC ASPECTS OF STRENGTHENING AND EXPANDING NATIONAL AND REGIONAL DATA BANKS AND ESTABLISHING AN INTERNATIONAL SPACE INFORMATION SERVICE AS A CO-ORDINATING CENTRE

Report of the Secretariat in response to the request of the Working Group of the Whole to Evaluate the Implementation of the Recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space

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BACKGROUND

1. The Working Group of the Whole to Evaluate the Implementation of the Recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE 82), in the report on the work of its fourth session, made a series of recommendations concerning the preparations of reports and studies by the Secretariat and the compilation of information from Member States (A/AC.105/456, annex II, paras. 4, 5 and 6).

2. In particular, in paragraph 4 (m), the Working Group

> "requested the Outer Space Affairs Division to prepare a report on the economic aspects of the implementation of the recommendation contained in paragraph 9 (b) of General Assembly resolution 44/46 [of 8 December 1989], on the basis of information provided by Member States and the reports of the United Nations meetings that have been held on the subject, so that at its next session the Working Group could examine in detail the most cost-effective and efficient ways of implementing the recommendation".

3. Paragraph 9 (b) of resolution 44/46 reads as follows:

> "Data banks at the national and regional levels should be strengthened and expanded and an international space information service should be established to function as a centre of co-ordination".

In the report of UNISPACE 82 (A/CONF.101/10 and Corr.1 and 2), this recommendation was contained in paragraph 211, with related recommendations contained in paragraphs 205 and 432.

4. The report of the Working Group was adopted by the Scientific and Technical Sub-Committee at its twenty-seventh session (A/AC.105/456, para. 21), and the recommendations were endorsed by the Committee on the Peaceful Uses of Outer Space at its thirty-third session 1/ and by the General Assembly in its resolution 45/72 of 11 December 1990, paragraph 10.

5. The Secretary-General, in a note verbale of 14 August 1990, called the attention of Member States to the recommendations of the Working Group of the Whole and to the recommendation of the Committee 2/ that information in response to the requests of the Working Group could be submitted as part of national reports on their space activities.

6. The reports on national space activities submitted by Member States are contained in document A/AC.105/470. While none of the reports submitted included information specifically in response to paragraph 4 (m) of the report of the Working Group, the information submitted has been taken into account in the preparation of the present report.

7. The present report has also taken into account the information contained in the reports of United Nations meetings on the subject organized as part of the

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United Nations Programme on Space Applications, in particular the report of the United Nations/Indian Ocean Marine Affairs Co-operation Conference Workshop on Oceanographic/Marine Space Information Systems (Karachi, 2-6 July 1989, A/AC.105/439), the United Nations Workshop on Regional Space Information Systems (Lima, 24-28 October 1988, A/AC.105/422) and the report on the United Nations International Meeting of Experts on Remote Sensing Information Systems (Feldafing and Oberpfaffenhofen, Germany, 7-11 May 1984, A/AC.105/343). Information from meetings on related subjects organized as part of the United Nations Programme on Space Applications has also been used.

8. Information on national information systems has previously been collected by the United Nations and published in document A/AC.105/397. Information on regional and international data banks is included in document A/AC.105/450.

INTRODUCTION

9. Satellites are used for a large variety of functions, including remote sensing, meteorology, communications, astronomy, upper atmosphere research and microgravity experiments. While all satellites generate some data, the question of data banks usually refers to the collection, storage, reproduction and distribution of data from remote sensing satellites, and to a lesser extent from meteorological satellites. This will be the subject of the present report. Before examining this question, however, it might be useful, for the sake of completeness, to take a brief look at other types of satellite data.

10. Communication satellites relay, from one Earth station to one or more other Earth stations, vast quantities of data, including telephone calls, television programmes, telex and facsimile signals and computer data. Communication satellites do not generate any of this data, but merely receive the radio signals carrying the data, amplify them, convert the signals to a different frequency and transmit them, without any processing or storage of the data on board the satellite. The data relayed by communication satellites can include data from other satellites such as remote sensing satellites; this is becoming increasingly important as a means of collecting data from remote sensing satellites. The relay of remote sensing satellite data by communication satellites will be considered below in section III on archiving satellite data. In addition to relaying data, communication satellites generate a small amount of data on the condition of the satellite, but these data are generally of interest only to the satellite operator and are of little or no relevance to the international question of data banks.

11. Scientific research satellites, including those for astronomy, planetary exploration and upper atmosphere research, generate a substantial quantity of data derived from their observations. These data, like remote sensing data, are transmitted to the ground, processed, stored, reproduced and distributed to users. Much of the analysis in the present report would also be applicable to these scientific data, although scientific data are distributed to users almost exclusively in the form of computer data, as opposed to photographic images. The problems of receiving, storing and reproducing computer data are largely independent of the type of data.

12. The sections that follow focus on data banks for remote sensing data, with consideration also given to the inclusion of meteorological satellite data for remote sensing applications. A review of the satellites that are generating data and the various types of data that they generate is followed by an examination of the organizational and economic aspects of establishing and strengthening data banks. Consideration is given not only to the organizational and economic aspects of the data banks themselves, but also to the context in which the data banks will be used, taking into account the need for education, training and user support. A final question to be considered is that of international co-ordination of data banks and the role of the International Space Information Service being established by the Outer Space Affairs Division of the United Nations Secretariat.

I. SOURCES OF SATELLITE DATA

A. Types of satellites

13. The present report is concerned with remote sensing data from satellites, including meteorological satellite data that can be used for environmental studies. The primary distinction between remote sensing and meteorological satellites is based on ground resolution and coverage, frequency of coverage and spectral response. Remote sensing satellites typically have a ground resolution between 5 and 80 m, they can cover a given area at intervals of a few days to a few weeks and the sensors are designed to detect small differences in ground brightness and colour. Meteorological satellite images, on the other hand, typically cover an area 2,500 to 4,000 km in width, with a ground resolution of 1 to 4 km, providing coverage at least twice a day, with sensors designed to distinguish between different types of clouds and measure their temperature and moisture content.

14. Daily coverage is an essential requirement for meteorological satellites, since weather is a rapidly changing phenomenon. Remote sensing, on the other hand, is generally used for more slowly changing features of the Earth's surface, and the high resolution required makes daily coverage impractical. For the same reasons, remote sensing data are of lasting value, while meteorological data are of more transient interest. Archives of remote sensing data are therefore generally of greater interest than archives of meteorological data.

15. The normal distinction between remote sensing and meteorological data, as outlined above, is not always applicable. The Advanced High Resolution Radiometer (AVHRR) on the meteorological satellites of the United States National Oceanic and Atmospheric Administration (NOAA), for example, which provides daily coverage with a resolution of 1 km in several spectral bands, has proved very useful for regular observations of vegetation conditions over large areas, and thereby for monitoring changing ecological conditions.

16. While the greatest quantity of remote sensing data has been obtained from automatic satellites such as the United States Landsat series and the French Spot series, which transmit data to the ground continuously in electronic form, data have also been physically returned to Earth, in the form of photographic film or computer tapes, from both automatic and crewed spacecraft. Photographs of the

Earth's surface were taken during United States crewed space missions, including Gemini, Apollo, Skylab and Shuttle missions, and image data on magnetic tape have also been acquired during Skylab and Shuttle missions. These data were acquired during missions lasting between a few days and a few months, using a variety of cameras, films and other sensors, and only a small portion of the missions were devoted to remote sensing. These data are therefore of modest historical significance.

17. The Union of Soviet Socialist Republics has brought photographic images back to Earth more regularly, both from long-term missions on the Salyut and Mir space stations and from the Cosmos series of automatic film-return satellites. These photographs, with a ground resolution of as low as 5 m, are the highest-resolution space images available. These data, however, are not routinely collected over other countries, but are acquired and distributed on the basis of specific applications and co-operative programmes between the USSR and the interested country.

18. Satellites carrying experimental sensors have also generated a certain amount of Earth observation data. Because of their experimental nature, the missions have generally been of a few years' duration and have generated data with a variety of sensors and data formats. Examples of such data include the radar images of both land and ocean areas from the United States Seasat experimental oceanographic satellite and images from the Coastal Zone Colour Scanner from the United States Nimbus-7 experimental meteorological satellite.

19. As the volume, variety and complexity of satellite data have increased over the years, the problem of acquiring, storing, reproducing and distributing data has expanded greatly. It has become quite impossible to acquire and store all of the Earth observation data over any country or region, and data banks must be selective in their acquisition of data. While some data are fairly clearly of greater general interest than other data, the choice will often depend on the specific interests of the users of a particular data bank. Data banks may have to decide, for example, on the relative priorities of land data versus coastal and marine data, or of historical data versus contemporary data, or data for local resource management versus data for regional ecological monitoring.

20. The sources and types of Earth observation data will continue to diversify for the foreseeable future and the volume of data will continue to accumulate rapidly. In addition to the continuing accumulation of image data from the Landsat, Spot, Resurs and Cosmos satellites, a number of imaging radar satellites are scheduled to be launched in the next few years, including the USSR Almaz station in 1990, the ERS-1 of the European Space Agency (ESA) in 1991, the Japanese JERS-1 satellite in 1992, and the Canadian Radarsat in 1994. In the longer term, Japan is planning the Advanced Earth Observing Satellite (ADEOS), the United States is planning a multi-component Earth Observation System (EOS), Brazil is planning a remote sensing satellite and other missions are being studied.

21. During the 1980s, the price of remote sensing data increased substantially. Both the United States and France have declared their intention of operating their remote sensing satellite systems, Landsat and Spot respectively, on a commercial,

cost-recovery basis. The USSR is offering its data for sale at comparable prices. A single image from those systems now costs from about $200 for the lower-resolution sensors to $4,000 for digital data from high-resolution systems. Financial considerations therefore will be an important determinant in the selection of data for a data bank.

B. Remote sensing satellite data

22. Landsat was the first, and for many years the only, regular source of satellite remote sensing data. The first satellite was launched in 1972, with Landsat-2 following in 1975, Landsat-3 in 1978, Landsat-4 in 1982 and Landsat-5 in 1984. Landsat-6 is to be launched in 1991. Landsat produces images covering an area 185 by 185 km, with a resolution of 80 m for the Multi-Spectral Scanner (MSS) and 30 m for the Thematic Mapper (TM). The four spectral bands of MSS and the seven bands of TM can be archived and used either as individual black-and-white images or combined into colour images. The data can also be acquired in the form of computer tapes. The satellites orbit in a near-polar orbit and cover the entire world in 16 days. The data are transmitted as they are collected, either directly to a ground station within sight of the satellite or via a relay satellite to a central ground station in the United States. Coverage of an area of 1,000,000 sq km would require about 50 images, allowing for overlap between the images and irregular boundaries of the coverage area. A global data bank of Landsat data, with reproduction and distribution services, is operated by the Earth Observation Satellite Company (EOSAT).

23. The first Spot satellite was launched in 1986, followed by Spot-2 in 1990. Spot-3 and Spot-4 are planned to ensure continuity of data through the 1990s. Spot images cover an area 60 by 60 km, and can be processed to black-and-white images with a resolution of 10 m or colour images with a resolution of 20 m and are also available as computer tapes. While the orbital cycle covers the entire world every 26 days, the High Resolution Visible (HRV) sensor has a mirror system which can be directed to either side of the sub-satellite track, enabling the sensor to cover selected areas more frequently. The side-looking capability also allows Spot data to provide stereo views that allow interpretation of topographic information. Spot data can either be received by a local receiving station or recorded on board the satellite and transmitted later to receiving stations in France and Sweden. Coverage of an area of 1,000,000 sq km would require about 350 images. A global data bank of Spot data, with reproduction and distribution services, is operated by Spot Image.

24. The USSR acquires photographic data using a variety of cameras carried on Cosmos satellites, with the film returned to the ground for processing. Data are available from the MKF-6 70 mm multiband camera and the KATE-200, KFA-1000 and MK-4 large-format cameras. These cameras take photographs with 60 per cent overlap for stereo, with resolutions between 5 m and 30 m, and covering areas from 75 sq km to 200 sq km. These cameras have been used to acquire similar photographs from the crewed Salyut and Mir space stations. The USSR also uses electronic imaging sensors on the Resurs satellites, which transmit data to the ground as they are collected. USSR remote sensing images can be acquired through arrangements with the Soyuzkarta agency.

25. In 1988, following the Bhaskara satellites launched in 1979 and 1981, India launched the Indian Remote Sensing (IRS) satellite carrying the Linear Imaging Self-Scanned sensors (LISS) providing four-channel multispectral data with either 36 m or 72 m resolution. Since there are no on-board tape recorders and data are not relayed by relay satellite, data can be acquired only for areas within the 2,500-km range of a ground receiving station. Currently, IRS data are received only by the ground station in Hyderabad, India, and hence the only foreign data that can be acquired are for the immediately surrounding areas. Data for the area covered are reproduced and distributed by the National Remote Sensing Agency.

26. Other historical remote sensing data have been obtained in smaller quantities from other spacecraft. The Skylab mission produced photographs with a resolution of 40-120 m; the Heat Capacity Mapping Mission (HCMM) produced thermal images of the Earth's surface with a resolution of 500 m; the Large Format Camera flown on the Space Shuttle produced photographs with a resolution of 10-30 m; and the Shuttle Imaging Radar (SIR) has produced radar images with resolutions of 15-40 m.

C. Meteorological and oceanographic satellite data

27. The meteorological satellites that are most widely used internationally for environmental monitoring are the United States NOAA satellites. The Advanced Very High Resolution Radiometer, with 1-km resolution and covering an area of about 2,500 km by 2,500 km, while designed primarily for cloud observations, has proved valuable for surface monitoring. Comparison of the brightness of the surface in the visible band and in the near-infrared band provides an index of the amount of green vegetation covering the ground. In arid and semi-arid areas, this index provides a valuable measure of the condition of the vegetation. While the daily coverage of large areas almost always includes cloud-covered areas, smaller cloud-free areas from successive days can be combined to generate cloud-free composites of large areas. A series of cloud-free composites, each combining 10 to 30 days of coverage, allows rapidly changing vegetation conditions to be accurately followed. The low resolution of the data make them of very limited use for mapping or local resource development purposes. While the original meteorological data are inexpensive to purchase or receive through a receiving station, the most useful form of imagery requires computer processing and film recording both for calculating the ratio of the two spectral bands and for combining daily imagery into large-area, cloud-free composites. Archives of these data are useful for long-term climatological and environmental research. Data from the NOAA satellites are available either by direct reception, with no access fee, or through the National Environmental Satellite Data and Information Service (NESDIS).

28. Geostationary meteorological satellite data have also been used for estimating rainfall, through the use of cloud-top temperature data. Geostationary satellites can provide data every 30 minutes, and these observations can be combined by computer to generate estimates of rainfall for periods of 10 to 30 days. This technique, using data from the European Meteosat, is the basis of the Africa Real Time Environmental Monitoring using Imaging Satellites (ARTEMIS) system of the Remote Sensing Centre of the Food and Agriculture Organization of the United Nations (FAO). The FAO Remote Sensing Centre maintains an archive of these data

for research purposes. Data from the Meteosat satellite are available either by direct reception, without access fee, or from the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT).

29. Other meteorological satellites, including the Soviet polar-orbiting Meteor satellites, the Chinese Feng-Yun polar-orbiting satellites, the United States Geostationary Operational Environmental Satellite (GOES) satellites and the Japanese Geostationary Meteorological Satellite (GMS), all with resolutions of 1 to 4 km, also provide limited information concerning large-scale surface conditions.

30. The United States experimental oceanographic Seasat satellite carried an imaging radar which, during its short-lived mission in 1978, collected imagery with a resolution of 25 m. While the radar system was designed for oceanographic observations, the images acquired over land areas also proved to contain useful information for mapping purposes.

31. The Japanese Marine Observation Satellite (MOS), launched in 1987, carries a Multispectral Electronic Self-Scanning Radiometer (MESSR) providing image data in the visible and near-infrared spectrum with 50-m resolution. Oceanographic satellites in the Cosmos series, such as Cosmos 1602, also provide oceanographic data, although these data have not been widely distributed. The Coastal Zone Color Scanner on the Nimbus-7 experimental satellite collected a large amount of data that are still useful for historical marine remote sensing studies. The limited availability of oceanographic remote sensing data has largely limited their use to research purposes, particularly in developing countries.

D. Ground stations

32. Data transmitted from satellites, such as Landsat and Spot, in electronic form is received at ground stations and recorded on magnetic tape. The data is then processed further to make them more readily useful to users, are distributed to users either as photographic images or computer tapes. The users can then use the data for making maps, identifying locations of interest, compiling statistics and other purposes.

33. Ground stations can receive data from a satellite during the period that the satellite is above the horizon as seen from the station site. For a satellite orbiting at an altitude of 700-800 km, a ground station can receive data covering a circle about 2,500 km in radius around the station site. Each day, the satellite will pass within range of the station for about 10 minutes in each of three orbits. For remote sensing satellites that do not provide full daily coverage, the orbits of subequent days will fill in the gaps between the orbits of the first day until coverage of the area is complete and the coverage cycle begins again.

34. Ground stations for receiving data from Landsat or Spot or both have been established in Argentina, Australia, Brazil, Canada, the Canary Islands (Spain), China, Ecuador, France, India, Indonesia, Italy, Japan, Pakistan, Saudi Arabia, South Africa, Sweden, Thailand and the United States. Ground stations in a number of other countries are planned. All of these ground stations are associated with processing facilities, data banks and user assistance services.

35. These stations receive and distribute data from the satellites on the basis of agreements with the satellite operators, the United States EOSAT Corporation in the case of Landsat, and the French Spot Image in the case of Spot. In the case of Landsat, the standard agreements call for the ground stations to receive and distribute data for the full territory covered by the station. The ground station operators pay an annual access fee of $600,000 to EOSAT. In the case of Spot, the agreements, negotiated for each station, specify the amount of data to be received, the areas to be covered and the access fee to be paid.

36. In addition to the national and regional data banks located at these ground stations, central global data banks exist, for Landsat at EOSAT in the United States, and for Spot at Spot Image in France. Data outside of the range of the central receiving stations are received through relay satellites in the case of Landsat and by on-board tape recording and delayed transmission in the case of Spot. The primary distributors for data from the various remote sensing and meteorological satellites are given in the annex to the present report.

37. Direct reception of meteorological satellite data requires no agreement and no fee. Because of the lower resolution and lower data rates, the receiving equipment is often less expensive as well. The data, however, may need computer processing to make them useful for environmental monitoring.

II. FORMS OF SATELLITE DATA

38. Data banks contain satellite data in various forms and generally also have information and data from other sources for use in conjunction with the satellite data. The most widely used form of remote sensing data, particularly in developing countries, is photographic images. Satellite data in photographic form can be processed and reproduced in a basic photographic darkroom and interpreted by conventional photo-interpretation techniques with simple equipment. The interpreted information can easily be compared with maps or transferred onto maps.

39. If a data bank is primarily for providing images for immediate consultation and use or as an index for ordering, the data should be in the form of black-and-white and colour prints and transparencies. If the data bank is an archive from which images are reproduced for distribution, the images should be in the form of black-and-white or colour negatives or colour transparencies.

40. Data in computer form allow certain types of processing that cannot be done with photographic data. Perhaps the most common use of computer processing is for enhancing images for specific purposes. Certain features, identified by their multi-spectral characteristics, can be highlighted in a computer-generated image, boundaries between features can be enhanced and subtle differences in relatively homogeneous areas such as water bodies can be amplified. Computer processing can also be used to compile statistics on the occurrence of certain features or to identify linear features. A computer processing capability requires not only computers and computer programmes but also high-quality film recorders and plotters to generate images or maps showing the results of the computer processing.

41. Data banks also require maps of the area served so that images can be located and compared with existing or historical map information. The maps can also be used as a geographic base for displaying information obtained from data interpretation. Maps at a variety of scales and of various dates should be collected whenever possible. In addition to standard topographic maps, thematic maps of geology, soils, land use, forests, administrative and political boundaries and other natural and human features should be collected.

42. In the case of national data banks, and where possible in the case of regional data banks, air photos should be included. Comparison of satellite images with higher-resolution air photos allows verification of satellite interpretation for selected areas and the comparison of the same area at different dates. While for most areas the earliest satellite images date from the 1970s, air photos from earlier decades provide a basis for the study of historical changes in land use or ecological conditions. Combining the satellite data bank with air-photo archives is generally the best way to facilitate combined use of the two sources. When a satellite data bank is established independently of air-photo archives, it is useful for the data bank to have indexes of available air photos and samples of photos from different air-photo projects.

43. Data banks should also generally have books and periodicals available for users. Books might include atlases, textbooks and reference books on remote sensing and photo-interpretation, reference books on the various satellites and sensors represented in the data bank and books on the geography of the area served. Periodicals would include journals of remote sensing and related fields and bulletins or newsletters from satellite operators or remote sensing organizations.

III. ARCHIVING SATELLITE DATA

44. Since a data bank is unlikely to have the resources to acquire, process, store and distribute all of the remote sensing data that exist for its area, data will need to be acquired selectively. The selection of data for a data bank will depend on the priority applications for which the data bank is to be used. The choices will depend on the resources or conditions to be studied, in particular on the relative priorities of land and marine observations, on the priorities of historical versus current data and on the priorities of mapping programmes versus continuous monitoring projects.

45. The first priority for any general data bank would probably be one high-quality, cloud-free remote sensing satellite image for all areas served by the data bank. Such a collection would probably meet the needs of most users, in particular for geological applications, cartographic mapping, ground-water prospecting, hydrological studies, many forestry applications and other applications studying features that are permanent or slowly changing. In areas with distinct seasons, additional data covering the entire area at one or more different seasons would be valuable since many features, such as rivers, lakes, forests and crops, may be easier to interpret in one season than another.

46. For studying changing features, a number of images of the area of interest, taken on different dates, is required. The study of historical changes will often require the acquisition of as many images as possible over as long a time period as possible. Since financial resources may not permit the acquisition of all existing images for the entire area covered by the data bank, priority areas for studying change may need to be selected.

47. The real-time study of rapidly changing phenomena, such as crops or floods, requiring two or more images within a few weeks or months, poses particular challenges to a data bank. If the data bank is associated with a ground station, it may be possible to arrange for priority collection and processing of the data required. If not, arrangements might be made with a ground station covering the area or a ground station with world-wide coverage capabilities, but rapid and reliable delivery of data from facilities in other countries has often proved difficult to ensure. Furthermore, accurate monitoring of many types of change requires very consistent data processing to ensure that differences between images are not the result of different processing, changing sensor characteristics or different observation conditions on different dates. Customized computer processing of the images may be necessary to ensure the comparability of the images.

48. Monitoring of more slowly changing phenomena such as land use patterns, deforestation or rangeland degradation have proved to be among the most valuable applications of satellite remote sensing. A set of Landsat data of a particular area, for a variety of dates between 1972 and the present, provides a unique set of data for examining changes in an area over the past two decades. Historical data sets of this type, at least for selected areas, would probably be a priority for most data banks.

49. Monitoring that does not require high-resolution data can take advantage of the frequent coverage and low cost of meteorological satellite data. Data from the Advanced Very High Resolution Radiometer (AVHRR) on the NOAA satellites, with daily coverage at 1-km resolution, have proved very effective for monitoring the condition of natural vegetation over extensive arid and semi-arid areas and identifying drought conditions or crop failures that require remedial action. While the cost of acquiring the data is low, the computer processing that may be necessary for accurate environmental monitoring increases the cost of these data. A data bank should probably have at least samples of meteorological satellite data for the entire area and should archive any data specially processed for environmental monitoring. Otherwise, data should be acquired only when there is a specific requirement for them.

50. For data banks covering marine regions, the acquisition of oceanographic satellite images may be a priority. However, a difficult question is whether to invest in facilities for the complex computer processing required for satellite imaging radar data, which provides unique information on sea-surface conditions. While satellite radar data are currently very limited in quantity and coverage, the situation will soon be changing. The USSR Almaz, the ESA ERS-1 satellite, the Japanese JERS-1 satellite and the Canadian Radarsat will soon be providing large quantities of radar data. A major advantage of radar, in addition to its oceanographic applications, is its ability to acquire imagery at night and through

clouds. None of these satellites, however, can record data, so data will be acquired only in areas that have ground stations. The processing of satellite radar data is substantially more complex and expensive than the processing of data from visible and infrared scanning sensors. Furthermore, since the data and their applications have been rather limited, a substantial amount of research, education and training may be necessary before data-bank staff and users are able to process and interpret the data effectively and efficiently.

51. Decisions would also need to be made concerning the format of the imagery. For photographic reproduction, the most flexible archival format may be 23 cm black-and-white negatives, which can be contact printed with very simple equipment and can also be enlarged or combined to produce colour prints. In cases where most users want colour prints or transparencies, however, colour transparencies may be a more efficient archival format, since making colour composites from black-and-white negatives is a time-consuming process. Whether black-and-white or colour, the 23-cm format is generally the best, since it is the standard for air photography, and a large variety of equipment is available for handling it.

52. Almost all data banks should have at least sample data in computer tape form. Data banks that are intended primarily for research use and that have computer-processing and film-recording capabilities may put higher priority on computer data than photographic data. At least sample computer data in the form of floppy disks for analysis by personal computers should also be acquired. The simplest computer-processing capability, although with a rather limited capacity, would be a personal computer with image processing software. It should be noted that the software may cost more than the computer. While such a system would allow experimentation, a film-recording system or digital plotter would also be required to produce useful images for accurate mapping purposes.

IV. DATA-BANK SUPPORT SERVICES

53. In most parts of the world, effective use of a satellite remote sensing data bank will probably require user-support services. Availability of education and training in image interepretation in the area served by the data bank would also be important for the long-term development of capabilities for using remote sensing for economic and social development. Since education and training programmes also require access to imagery for their programmes, the ideal situation is the development of remote sensing centres that combine a data bank, user service and training programmes, and including or affiliated with advanced educational institutions. Where some of these facilities or services already exist but are without a data bank, within educational institutions for example, the data bank might best be established as part of, or at least closely affiliated with, the existing facilities.

54. User services should include consultation on selection of imagery, advice on equipment and techniques for image interpretation, assistance with interpretation techniques and special photographic or computer processing for special interpretation requirements. Since some user organizations may have only occasional requirements for remote sensing and may not have staff available for

training, they may wish to have the interpretation done on a contractual basis. A data bank that could make interpretation services available, using either data-bank staff or other trained interpreters on a contractual basis, could avoid the need for foreign contracts for such work.

55. Training programmes offered by the data bank could range from one-day seminars on the data, equipment and services offered by the data bank to workshops and training courses lasting from one week to one year on data interpretation. In addition to a regular programme of such activities at the data bank, data-bank staff could also give lectures, seminars or short courses at user organizations. This short-term training would not only promote the use of remote sensing in the region but would also provide trained people for the staffing needs of the data bank.

56. Longer-term education in remote sensing, one year or more in duration, might best be carried out by advanced educational institutions offering degrees. Co-operation between the data bank and the institution could take the form of provision of data and services, exchange of students, exchange of staff and exchange of consulting services. The graduates of such programmes would also provide potential recruits for data-bank staff. Long-term training could also be provided through on-the-job training with specialists at the data bank.

V. ECONOMIC ASPECTS OF DATA BANKS

57. The cost of establishing a data bank will vary greatly depending on the size of the area to be served, the amount and types of data to be included, the amount of processing and interpretation equipment and the number of staff. Furthermore, since most regions of the world already have some facilities offering services in remote sensing, much of the need for data banks could be met by strengthening existing facilities rather than establishing new ones. The cost of strengthening existing facilities would similarly vary greatly depending on the capabilities of existing facilities. The cost of meeting the needs of an area for new or improved data-bank services would therefore have to be calculated taking into account the specific requirements of the area.

58. In order to provide an indication of the costs of various facilities, some very approximate cost estimates are provided below for a sample case, that of a developing country or region with an area of 1,000,000 sq km, with no existing facilities. The data bank includes image archives, reference information, a photographic processing facility, some simple photo-interpretation equipment and a personal-computer based image processing system. The images will include a mixture of Landsat MSS and TM images, Spot images, Cosmos photographs and samples of other satellite data, purchased from international sources. No expenses related to a ground receiving station are included. The cost of the building for the data bank, vehicles and other general supplies and services is not included since such costs are best determined locally.

59. Some approximate cost estimates for various elements that might be acquired as part of the establishment of a data bank are as follows:

	$
Satellite imagery	
Complete coverage, two seasons	240 000
Selected coverage, multiple/stereo	100 000
Computer data, selected coverage	20 000
Other imagery: meteo, ocean, radar, etc.	20 000
Maps, books, periodicals	20 000
Photographic processing equipment	100 000
Interpretation equipment	40 000
PC-based image processing system	100 000

60. In addition to the basic collection of imagery acquired for the establishment of the data bank, new imagery would need to be acquired on an ongoing basis for monitoring purposes and as new satellites and sensors are launched. A rough guideline for estimating costs might be that 10 per cent of the area might be covered by new imagery each year. New types of data and new techniques of data processing and interpretation would also require some new equipment. The support information such as maps, books and periodicals would also need to be kept up to date.

61. A major operational cost of the data bank would be the salaries of personnel, which, for a basic operation, might consist of four professionals, two technical staff and two clerical staff. These would manage the data bank, reproduce and distribute data, advise and assist users and conduct short-term training sessions.

62. Planning for a data bank would also need to include estimates of the continuing costs of operations and maintenance, including power, communications, transportation, photographic supplies, interpretation materials, computer supplies and office supplies.

VI. REGIONAL AND INTERNATIONAL CO-OPERATION

A. Regional data banks

63. Remote sensing centres and data banks already exist in many countries in all regions, some based on remote sensing satellite ground stations. Many of these centres already provide some services to neighbouring countries, either formally or informally, including data reception, processing and distribution, training and user assistance. Where more complete or expanded regional services are desirable, these national facilities could provide an experienced base for a regional

facility. It would seem likely that substantial savings could be realized by taking advantage of existing facilities, rather than creating new facilities.

64. Two regional remote sensing centres have been established in Africa, at Ile-Ife, Nigeria and Ouagadougou, under the sponsorship of the United Nations Economic Commission for Africa (ECA). These centres include regional data banks and process and distribute data, as well as providing training and user assistance for agencies in the region. The further development and strengthening of those regional centres would provide valuable support to the use of remote sensing in Africa.

65. In Asia, there is no regional data bank that collects, processes and distributes satellite remote sensing data, but the Regional Remote Sensing Programme of the Economic and Social Commission for Asia and the Pacific (ESCAP) at Bangkok provides a co-ordinating function and an information service for the region. The Regional Remote Sensing Programme maintains computer data bases on remote sensing literature and remote sensing experts in the region. The Asian Institute of Technology, also in Bangkok, offers education and training in remote sensing for the region. The establishment of a regional data bank for the Asia and the Pacific region should probably be carried out in co-operation with those organizations.

66. In Latin America, there is no regional facility, but the Sociedad de Especialistas Latinoamericanos en Percepción Remota (SELPER) provides a mechanism for exchange of information and co-ordination of activities. Another current regional co-operative activity is the follow-up to the Space Conference of the Americas, being co-ordinated by the Ministry of Science and Technology of Costa Rica. The establishment of a regional data bank for Latin America should probably be co-ordinated with those regional efforts.

67. For Western Europe, the European Space Agency operates remote sensing satellite ground stations in Italy, Spain (Canary Islands) and Sweden and distributes data through the Earthnet system and the commercial Eurimage consortium. These data cover Western Europe and parts of North Africa and West Africa. In addition to the data archives, the ESA Information Retrieval System provides a computerized information service.

68. As part of the effort to promote the use of remote sensing through regional co-operation, the Outer Space Affairs Division, as part of the United Nations Programme on Space Applications, has prepared project proposals for the establishment of regional centres for space science and technolgy education, with initial emphasis on educational programmes in remote sensing in the Africa, Asia and the Pacific, Latin America and West Asia regions. These proposals are in response to General Assembly resolution 44/46, paragraph 9 (c), which called upon the United Nations to support the creation of adequate training centres at the regional level, an appeal which was repeated in resolution 45/72. The proposals also respond to the recommendation of the Working Group of the Whole of the Scientific and Technical Sub-Committee to implement the recommendations of UNISPACE 82 that the United Nations should lead, with the active support of its specialized agencies and other international organizations, an international effort

to establish regional centres for space science and technology education (A/AC.105/456, annex II, para. 4 (n)). These centres, while not intended to include full regional data banks, would include some facilities for processing and intrepreting data, and should have close ties to data banks serving the region concerned. Where regional data banks do not exist, consideration could be given to establishing them in conjunction with those centres.

B. International co-ordination

69. As noted above, the operators of remote sensing, meteorological and other environmental survey satellite systems operate data banks which provide reproduction and distribution services on a global basis. Such services are offered by EOSAT, NESDIS, Eurimage, Spot Image and Soyuzkarta. In addition, many satellite ground station operators provide data reproduction and distribution services to neighbouring countries.

70. International co-ordinating groups of satellite operators and of ground station operators have been established to co-ordinate the design and operation of remote sensing and meteorological satellites and the reception and processing of satellite data. These working groups promote the compatibility and complementarity of satellite systems and data formats.

71. A number of international organizations promote and co-ordinate the global exchange of meteorological and environmental satellite data and satellite-derived information. The World Meteorological Organization (WMO) co-ordinates the World Weather Watch programme which includes a Global Telecommunications System for regular international exchange of meteorological data, including satellite-derived data. The United Nations Environment Programme (UNEP) is co-ordinating and operating the Global Resource Information Database (GRID), which will archive and disseminate global environmental data, including satellite-derived data. As part of the International Geosphere-Biosphere Programme (IGBP), co-ordinated by UNEP, the United Nations Educational, Scientific and Cultural Organization (UNESCO) and WMO, a study is being conducted to determine the needs for a data and information system for the study of global change.

72. The FAO Remote Sensing Centre is developing a remote sensing information data base consisting of the World Index of Space Imagery (WISI) and a World Aerial Photographic Index (WAPI), with initial priority given to African countries and other developing countries. The programme will link national and international remote sensing data bases and assist in upgrading national data bases in developing countries. FAO also provides training, advice and technical assistance in the use of remote sensing data for management and monitoring of renewable resources.

C. The International Space Information Service

73. The UNISPACE 82 Conference recommended the establishment of an international space information service in the Outer Space Affairs Division of the Secretariat, consisting initially of a directory of sources of information and data services

(A/CONF.101/10, para. 432). As with other recommendations, this was to be implemented through voluntary contributions by Member States. While no voluntary contributions have been received for the Service, the existing resources of the Outer Space Affairs Division have been used to begin the strengthening of the services of the Division in providing information on request to Member States and regional organizations. In the absence of any increase in resources available to the Division, the improvement in the provision of information in response to requests from Member States has been due largely to the adoption of computer-based information processing systems.

74. In response to the UNISPACE 82 recommendation concerning the International Space Information Service, the Outer Space Affairs Division has, as an initial step, prepared and distributed to the Committee on the Peaceful Uses of Outer Space and to Member States a number of directories of sources of information and data services. The publication "Space Activities of the United Nations and International Organizations" (A/AC.105/358) provides information on the activities and services of the United Nations, the specialized agencies and 11 other regional and international organizations involved in space activities, and on how to contact the organizations for further information. The publication "Information Systems on Space Science and Technology: A Directory" (A/AC.105/397/Rev.1) provides information on 91 national sources of information in 46 countries and on 5 regional and international organizations that provide information. The publication "Education, Training, Research and Fellowship Opportunities in Space Science and Technology and its Applications: A Directory" (A/AC.105/432) provides information on 138 education and training programmes in 38 countries and 10 programmes in 5 regional and international organizations. The list of experts in space technology and applications (A/AC.105/460 and Add.1) provides a list of individuals and institutions that can be contacted for expert advice and assistance in various areas of space activities.

75. While the Outer Space Affairs Division does provide Member States, on request, with information on sources and types of satellite data and with advice on developing and strengthening remote sensing programmes, it has neither the mandate nor the resources to provide international co-ordination of data banks or information services.

VII. CONCLUSIONS

76. Given the existence of satellite operator data banks that provide global reproduction and distribution services, regional data banks in many parts of the world and international environmental data exchange mechanisms co-ordinated by international organizations, there would not appear to be an urgent need for a new global data bank. Such a data bank would be very expensive, would not effectively meet the particular needs of countries and regions and would be largely redundant in the light of existing facilities and services. The establishment of a new global data bank would probably be much less cost-effective than strengthening existing regional or subregional facilities or establishing such facilities in regions where they do not exist.

77. While the costs of strengthening or establishing a national or regional data bank are too dependent on the specific needs of the users, some general indications of the cost of data, supporting information and equipment have been given in chapter V above and can be used as a basis for more precise estimates for particular projects. Funding for strengthening or establishing national or regional facilities might be obtained from a variety of sources, including the host country, participating countries of the region, other countries providing bilateral or multilateral assistance and international technical assistance agencies. In general, a combination of sources would be the best way to raise funding for the variety of data, equipment, services and expertise that would be required for the data bank. It should be recognized, however, that the duration of outside assistance is generally limited to a few years and the long-term viability of the data bank would depend on ongoing financial commitments by the host country and the participating countries of the region.

78. The cost of remote sensing data is a major factor limiting the wider use of such data and constraining the expansion of existing regional and national data banks and the establishment of new data banks, particularly in developing countries. This constraint, however, cannot be eliminated through the establishment of new data banks, but depends rather on how remote sensing satellite systems, including ground stations and processing systems, are to be financed. The costs of developing and operating remote sensing satellites and ground stations are still subsidized to a substantial extent by the Governments concerned, despite some efforts to make the systems commercially viable. The cost of data to users can be reduced below current levels only through further subsidies for system operating costs, including the costs of ground stations and data processing. Meteorological satellite data are substantially less expensive since the system development and operating costs are borne by Governments as a public service.

79. In general, the existing mechanisms for international co-ordination of satellite systems and for providing access to remote sensing, meteorological and environmental data and satellite-derived data are adequate, although further strengthening of such mechanisms, in particular to facilitate access by developing countries, would promote broader use of remote sensing and broader participation in environmental monitoring efforts. The needs of users are probably best served by national user assistance centres including national data banks, linked to regional centres and ground stations, which in turn are linked to satellite operators and global data banks. Co-ordination of national and regional access to remote sensing data can also help to address political problems relating to access to data.

80. There is a continuing need for information, education and training, and technical and financial assistance to enable developing countries to make full use of satellite remote sensing and environmental monitoring systems. Within the United Nations system assistance is provided by the United Nations Programme on Space Applications (Outer Space Affairs Division), the Natural Resources and Energy Division (Department of Technical Co-operation for Development), the FAO Remote Sensing Centre, WMO, the United Nations Development Programme (UNDP) and the World Bank. All of these bodies, however, are severely limited in the resources available to them and are unable to fully meet the needs of developing countries for such assistance.

81. The Outer Space Affairs Division is making efforts to further develop and improve the International Space Information Service, using existing resources, to help meet the needs of Member States for information and advice relating to space science, technology and applications. A major contribution to this effort could be made through voluntary contributions towards improved facilities for information processing, either in the form of equipment or in access to national or international information systems.

82. The strengthening of data banks on the national and regional levels, the further development of co-ordinated international environmental monitoring programmes, improvements in the dissemination of information and expansion of international technical assistance are all important activities in the promotion of satellite remote sensing and environmental surveys for social and economic development, based on international co-operation.

Notes

1/ Official Records of the General Assembly, Forty-fifth Session, Supplement No. 20 (A/45/20), para. 30.

2/ Ibid., para. 139.

Annex

SOURCES OF SATELLITE DATA AND INFORMATION

Primary distributors of satellite data

ESA Earthnet, IRS

European Space Research Institute
Via Galileo Galilei
00044 Frascati, Italy
Tel. (39) 69 48 01
Telex 610637 ESRIN I
Fax (39) 694 18 03 61

Landsat

EOSAT
4300 Forbes Boulevard
Lanham, Maryland 20706, USA
Tel. (USA) (800) 344-9933
(Intl) (01-301) 552-0569
Fax (301) 552-5476
Telex 27768 LSAT

Spot

Spotimage
16 bis, avenue Edouard-Belin
F 31030 Toulouse Cedex, France
Tel. 33-61 53 99 76
Telex 532 079 F
Fax 33-61 28 18 59

Indian Remote Sensing Satellite (IRS)

National Remote Sensing Agency
Balanagar, Hyderabad 500037
India
Telex 04256522

Japanese satellites

Earth Observation Satellite Group
National Space Development Agency
World Trade Center Building
2-4-1 Hamamatsu-cho, Minato-ku
Tokyo 105, Japan
Tel. 81-3-5470-4111
Telex J28424 NASDA
Fax 81-3-433-0796

USSR satellites

Soyuzkarta
45, Volgogradsky Prospekt
Moscow, 109125, USSR
Tel. 177-40-50
Telex 411942 REN SU

United States meteorological satellites

Satellite Data Services Division
National Environmental Satellite Data and Information Service (NESDIS)
National Oceanic and Atmospheric Administration (NOAA)
World Weather Building, Room 100
Washington, D.C. 20233
Tel. (301) 763-8111

United Nations remote sensing information sources

FAO

Remote Sensing Centre (AGRT)
Via delle Terme di Caracalla
00100 Rome
Italy
Tel. 57971
Telex 610181 FAO
Fax 6799563

UNEP

United Nations Environment Programme
P.O. Box 30552
Nairobi, Kenya
Tel. 333930, 520600
Telex 22068 UNEP
Fax (2542) 520771

International Space Information Service

International Space Information Service
Outer Space Affairs Division
United Nations, NY 10017, USA
Tel. (212) 963-6051
Telex 62450 UNATIONS
Fax (212) 963-4879